



# The evidential value of singed hairs in arson cases

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## ABSTRACT

The prevalence of singed hairs on hands was examined in a representative sample comprised primarily of Hamburg LKA staff members to determine the evidential value of such traces in criminal cases. Hair samples were taken from the hands of 160 subjects and examined under a microscope. Evidence of singing was found in 53 of the samples. These traces were largely restricted to a limited number of areas. Distribution of singed hairs over a wide area was observed in just 3 subjects all of whom reported contact with an open flame. The presence of singed hair on the back of the hand can be of great evidential value, though the corresponding distribution pattern must be carefully interpreted.

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## 1. Introduction

Many German State Offices of Criminal Investigation (LKA) regularly test potential arsonists for evidence of burn damage to the hairs on the back of the hand and on the head. Such examinations prove to be particularly useful if volatile accelerant was used in setting the fire. These accelerants often mix with the air to create an incendiary mixture that can cause a deflagration when ignited. The perpetrator is then exposed to the expanding flame which can reach very high temperatures, but is generally of extremely short duration and therefore does not result in serious burns to the skin.

Investigations done at the Bavarian Office of Criminal Investigation [1,2] have however shown that even high temperatures of short duration can result in typical singing pattern on the hair of perpetrators. These types of singing patterns on human hair on the head and back of the hand were described in detail by Lochte [3] and later by Richter Henson and Rowe [4].

The question still remains however to what extent damage caused to the hair by heat can be directly connected to an individual case of arson, and to what extent singing of the hair is caused by daily use of fire or other sources of heat such as while smoking, lighting a fire in a fireplace, cooking over an open flame, ironing, using candles etc. To date no studies have investigated these effects.

The goal of this study was therefore to investigate the prevalence of trace evidence of burn damage to the hair in the population as a

whole and to specifically document the respective burn patterns, that is the distribution of damaged hairs on the hands.

## 2. Material and methods

To determine the prevalence of singed hairs, samples were taken from both hands of 160 subjects of different ages (most of whom were Hamburg LKA staff members) over a time period from mid-February to mid-March 2009. The study group comprised of 53 women (33.1%) and 107 men (66.9%).

A special razor which has proven effective in routine investigations by the LKA Hamburg (Efalock Professional Tools, Point Razor) was used to collect the samples. The hairs were removed using the razor and immediately lifted using an adhesive tape such as is used in the routine collection of fibre evidence [5,6]. The tape lifts were then affixed inside colourless transparent plastic envelopes. During sampling each individual finger, the back of the hand, and the wrist area were treated as separate areas. After a sample was collected from one area, the razor was thoroughly covered with adhesive tape lifts to collect all the hair and prevent the transfer of trace evidence to the next area to be sampled. In contrast to routine case investigation undertaken by the LKA Hamburg in which the razor is used once on a single individual and then discarded, here the razor was used on multiple persons and thoroughly cleaned and disinfected between subjects.

In addition to sample collection, test subjects were interviewed about their smoking habits and possible contact with fire or open flames and regarding any recent burns.

The hair samples collected were examined using stereo and transmitted light microscopy for evidence of heat damage. Any singed hairs found were counted for each individual area and entered into a table (Table 1).

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**Table 1**  
Distribution of singed hairs among test persons with positive test results.

Number	Gender	Smoker	Left hand							Right hand						
			t	f	m	r	l	b	w	t	f	m	r	l	b	w
2	Female	No	–	–	–	–	–	–	–	–	–	–	–	–	–	1
3	Female	No	–	–	4	–	–	–	–	–	2	–	–	–	–	–
5	Female	Yes	–	–	–	–	–	–	–	–	1	–	–	–	–	–
6	Male	Yes	–	–	–	–	3	–	–	–	–	–	–	–	–	–
7	Female	No	–	–	–	–	–	–	–	–	1	–	–	–	–	–
8	Male	No	–	–	–	–	–	–	–	–	–	–	–	9	1	–
11	Female	No	–	1	–	–	–	–	–	–	–	–	–	–	–	–
13	Female	No	–	–	–	–	–	–	–	–	3	5	1	–	–	–
14	Female	No	–	–	–	–	–	–	–	–	–	–	–	2	–	–
15	Male	Yes	–	–	–	–	–	–	–	–	2	–	–	–	–	–
16	Male	Yes	–	–	–	–	–	–	–	–	1	–	–	–	–	–
18	Female	Yes	–	–	–	–	–	–	–	–	3	–	–	–	–	–
30	Male	Yes	–	–	–	–	–	–	–	–	1	9	–	–	–	–
32	Female	Yes	–	–	1	–	–	–	–	–	–	–	–	–	–	–
33	Male	Yes	–	–	–	1	–	–	–	–	1	2	–	8	–	1
34	Male	Yes	–	–	–	–	–	–	–	–	3	–	–	1	–	–
38	Male	Yes	–	–	–	–	–	–	–	–	1	2	1	–	3	–
39	Male	Yes	2	11	1	–	–	–	–	5	10	3	–	–	–	–
40	Female	Yes	–	13	20	15	5	–	–	–	3	3	–	–	–	1
44	Male	No	–	–	–	–	–	–	–	–	–	1	–	–	–	–
45	Male	No	–	–	–	–	–	–	–	–	1	–	–	1	–	–
50	Male	No	–	–	1	–	–	–	–	–	–	4	–	–	–	–
51	Female	No	–	–	–	–	–	–	–	–	1	–	–	–	–	–
55	Male	No	–	–	–	–	–	–	–	–	1	–	–	–	–	1
56	Female	No	–	–	–	–	–	–	–	–	6	22	23	6	1	1
62	Female	No	–	–	–	–	–	–	–	–	27	8	7	8	2	1
64	Male	Yes	–	20	2	–	1	–	–	5	2	1	1	7	–	–
72	Male	Yes	2	–	–	–	–	–	–	–	–	–	–	–	–	–
77	Female	Yes	–	–	–	2	–	–	–	–	–	–	–	–	–	–
82	Female	No	–	–	–	–	–	–	–	2	4	3	1	1	–	–
83	Male	No	–	–	–	–	–	–	–	2	–	–	–	–	–	–
86	Female	No	6	–	3	2	–	–	–	–	2	–	–	–	–	–
91	Male	No	1	–	–	–	–	–	–	2	3	–	5	–	–	–
92	Male	No	–	–	–	–	–	–	–	1	–	–	–	–	–	–
93	Male	No	–	–	–	–	–	–	–	–	–	1	–	–	–	–
97	Male	No	–	–	–	–	–	–	–	–	–	2	–	–	–	–
99	Female	No	–	–	–	–	–	–	–	–	–	–	4	4	1	–
103	Female	Yes	2	–	–	–	–	–	–	–	2	–	–	–	–	2
104	Male	Yes	–	–	–	–	–	–	–	17	–	2	–	–	–	–
107	Female	No	–	–	–	–	–	–	–	1	1	–	–	–	–	–
115	Female	No	–	–	–	–	–	–	–	–	5	–	–	–	–	–
116	Male	No	–	–	–	–	–	–	–	14	2	4	7	2	–	–
119	Male	No	–	–	–	–	–	–	–	–	–	–	–	–	–	1
122	Male	No	–	15	4	1	–	–	–	–	5	1	–	–	–	–
132	Male	No	–	–	–	1	–	–	–	–	3	6	–	1	–	–
133	Male	No	–	–	–	–	–	–	–	–	2	–	–	–	–	–
135	Male	Yes	–	–	–	–	2	–	–	–	1	–	–	–	–	–
136	Male	Yes	–	–	–	–	–	–	–	–	1	3	–	–	–	–
140	Male	Yes	1	–	–	–	–	–	–	–	3	3	–	–	–	–
143	Male	Yes	–	–	–	–	–	–	–	1	–	–	–	–	–	–
151	Male	Yes	–	1	–	–	–	–	–	4	7	2	–	–	–	–
157	Male	No	–	–	–	–	–	–	–	–	2	–	–	1	–	–
158	Male	Yes	1	2	–	8	6	13	4	–	1	–	–	2	–	–

t = thumb, f = forefinger, m = middle finger, r = ring finger, l = little finger, b = back of the hand, w = wrist.

### 3. Results

The test group of 160 subjects included 52 smokers (32.5%), of these 37 were men and 15 were women. Around one-third of all test subjects (54 people, 33.8%) reported regular contact with open flames where the most common source was a fireplace. 27 (16.9%) people reported having experienced burns on their hands in the past 2 to 3 months.

Evidence analysis noted traces of singed hairs in 53 (33.1%) of persons tested. Among the smokers this group comprised 23 people or 44.23% of all smokers, only a slight increase with respect to the group as a whole. Around half (51.9%) of those who reported contact with an open flame also had singed hairs. The percentage of people in the group who reported suffering burns in the past 2 to 3 months showed a dramatic increase of 81.5%.

In nearly two thirds (64.2%) of those test subjects with singed hairs, these were only observed in one or two areas. The number of subjects exhibiting singed hairs in more than two areas dropped sharply in inverse correlation with the increasing number of areas affected (Fig. 1).

Singed hairs on the back of the hand or wrist were only found in 12 people (7.5%). Burn damage distributed over a large area and affecting both the wrist and back of the hand and a number of fingers was only observed in three test subjects (1.9%). In these three cases the burn damage was largely restricted to one hand. All those affected reported burns from an open flame as the cause.

### 4. Discussion

The widespread presence of singed hairs in 33.1% of all test persons who partook in the study is quite striking. The fact that at

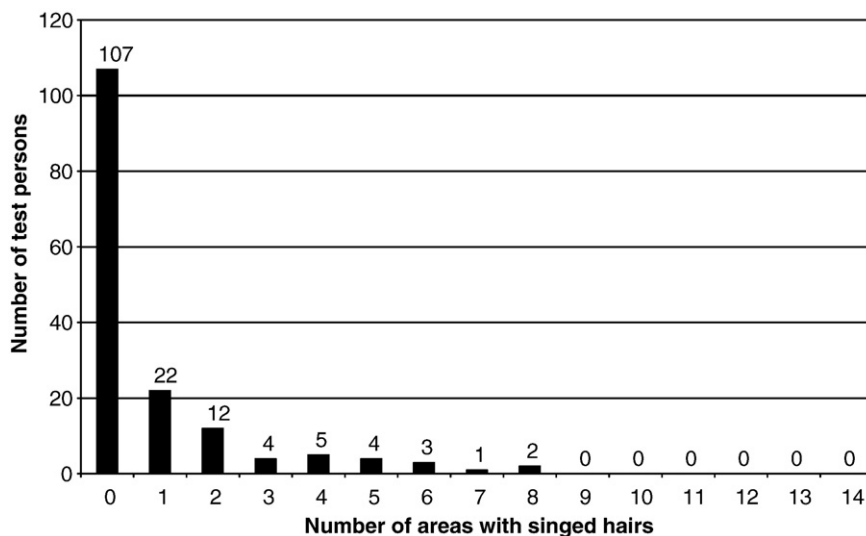


Fig. 1. Distribution of the number of test persons according to number of areas exhibiting singed hairs.

least individual hairs showing signs of burn damage are present in around every third person emphasises how important the careful interpretation of such data is in case work.

Based on the results presented here, arson cases in which no volatile accelerant was used and in which there was therefore no deflagration cannot be expected to leave a pattern of trace evidence that could be distinguished from the pattern of burn damage caused by cigarette smoking for example. Unless, of course, the perpetrator came in direct contact with the heat of the spreading fire at the scene after the fire had been started.

According to the results of this study, the presence of heat-damaged hairs in only one or two areas can in no way be interpreted as evidence of possible involvement in arson.

It should also be noted that not a single one of the test subjects exhibited singed hairs in all the areas of both hands from which hairs were collected (Fig. 1). The largest number of areas showing singed hairs in this study was found on two subjects with eight areas respectively (Fig. 1). This clearly demonstrates that the distribution pattern is extremely important when collecting and analysing such trace evidence.

Heat sources with small circumferences such as lighters and candle flames or the lit end of a cigarette leave evidence of burn damage within the expected range and limited to just one or only a few neighbouring areas of the hands. Conversely, with increasing size of the heat source, the heat damage it causes to the hairs on hands and wrists can be expected to be spread over a correspondingly increasingly large area. In this study all subjects who exhibited burn damaged hairs spread out over a larger area reported larger heat sources such as fireplaces or the flames in a gas stove as the probable cause for those traces.

For the results of an investigation to be meaningful, it is therefore imperative to isolate different areas such as each individual finger, the back of the hand and the wrist area when gathering evidence. This is the only way the wide distribution of heat-damaged hair can be proven later.

The samples in this study were taken during the winter months of February and March. Since experience has shown that at least partial evidence of heat damage to hair remains over a period of at least two months, the time the period in which the heat damage noted in the study occurred would have been from mid-December to mid-March. This time period therefore covers much of the time in which fireplaces are often lit and also includes the holiday season in which candles are often lit for a cosy atmosphere. It is possible that the percentage of the population exhibiting heat damage to hair on the hands would be

lower at other times of the year. There are however other times in a year, such as barbeque season, when a significant increase in the prevalence of evidence of heat damage to hair might be expected in the population.

In the investigation undertaken here it was noted that as a rule only a few hairs within each affected area exhibit evidence of heat damage and that other hairs from the same area are completely undamaged. This observation is in keeping with findings to date from investigative work undertaken by the LKA Hamburg. This fact can probably be explained by the different levels of exposure of individual hairs. One can assume that those hairs that are almost parallel to the surface of the skin are less exposed than those that stick out at a right angle from the hand. This emphasises the extreme importance of evidence collection. When collecting evidence, care must be taken to ensure that as much of the hair as possible is collected, in particular from the fingers. Spot testing is only sufficient for the more hirsute areas of the back of the hand and the wrist, and then only in some cases. In investigations run by the LKA Hamburg and in this study, the use of a hair trimmer (e.g. the model made by the Efalock company) proved much more effective than the use of dissecting scissors or nail scissors would have been.

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## References

- [1] H. Pabst, Versengungen an Haaren, Kriminaltechnisches Symposium "Allgemeine Biologie", Kiel, 1997.
- [2] H. Pabst, Kurzzeitige Hitzeeinwirkung auf Haare, in: M. Oehmichen (Ed.), Research in Legal Medicine, Vol. 21, Schmidt-Römhild Verlag, Lübeck, 2000, pp. 293–303.
- [3] T. Lochte, in: J.J. Weber (Ed.), Atlas der Menschlichen und Tierischen Haare, Vol. 1–3, Leipzig, 1938.
- [4] C. Richter Henson, W.F. Rowe, The effect of elevated temperature on the microscopic morphology of human head hair, *Microscope* 50 (2002) 21–24.
- [5] J. Robertson, C. Roux, From the crime scene to the laboratory — transfer, persistence and recovery of fibres, in: J. Robertson, M. Grieve (Eds.), Forensic Examination of Fibres, Second ed., Taylor & Francis, London, 1999, pp. 89–100.
- [6] F. Springer, From the crime scene to the laboratory — collection of fibre evidence from crime scenes, in: J. Robertson, M. Grieve (Eds.), Forensic Examination of Fibres, Second ed., Taylor & Francis, London, 1999, pp. 101–115.